Integration of AVM iFAB Tools for Industrial Use
DMDII-14-01-09
Penn State Applied Research Laboratory

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Agenda

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1. Project Background
2. Problem Statement
3. Proposed Solution
4. Scope of Work / Manufacturing Analysis System Components
5. Assisting Organizations
6. Success Criteria

Background

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- DARPA Adaptive Vehicle Make (AVM)
  - Portfolio of programs aimed at reducing development time of complex weapon systems
- iFAB Foundry – manufacturing component of AVM
  - Manufacturability Assessment
    - Provide automated feedback to designer
    - Cad-embedded Design Assist Tools to support manufacturable designs
    - Primary metrics: Cost and Lead Time
  - Foundry Configuration
    - Pareto front of build plan alternatives
    - Schedule development and decision-maker analysis
  - Manufacturing Execution
    - Generate and maintain machine code, work instructions, and tech data
    - Handle work plan exceptions and problem reports
    - Provide build status/As-built TDP

Background
Design (for Manufacturability) Assist Tools - DATs

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- AVM Challenges/Discoveries
  1. Design (for manufacturing) environment must be in CAD software
  2. Designs must contain enough "manufacturing data" for analysis
  3. Guiding/Constraining designers increases likelihood of manufacturable design (or within cost/lead time targets)
- ARL Penn State developed Design Assist Tools to be used by designers within the Creo environment
  - Guide: offering valid options for materials, part classes, welds, etc. that results in data specification used in manufacturability analysis
  - Constrain: limit options to what is supported in component and manufacturing model libraries; *rejecting non-iFAB-able designs*
- HuDAT – Hull Design for Manufacturability Assist Tool
- MAAT – Manufacturing Analysis Augmentation Tool

Problem Statement

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- **Problem Statement Overview**
  - Current ability to conduct detailed manufacturability assessments and cost roll-ups throughout the design process requires human-in-the-loop interaction
  - Early detection of manufacturability issues or expected excessive costs prior to manufacturing release will reduce product cost and total development time
- **Current State Baseline**

Process	Industry Standard	Current State of Research (AVM)
Manufacturing Data Specification	Manual; lacking in concept/early design; insufficient for analysis	CAD-embedded Design Assist Tools (DATs)
Manufacturability Analysis; Product Cost Estimating	Manual; post-design; time consuming; lack of cost roll-ups	Automated manufacturability assessment / cost estimating

Problem Statement

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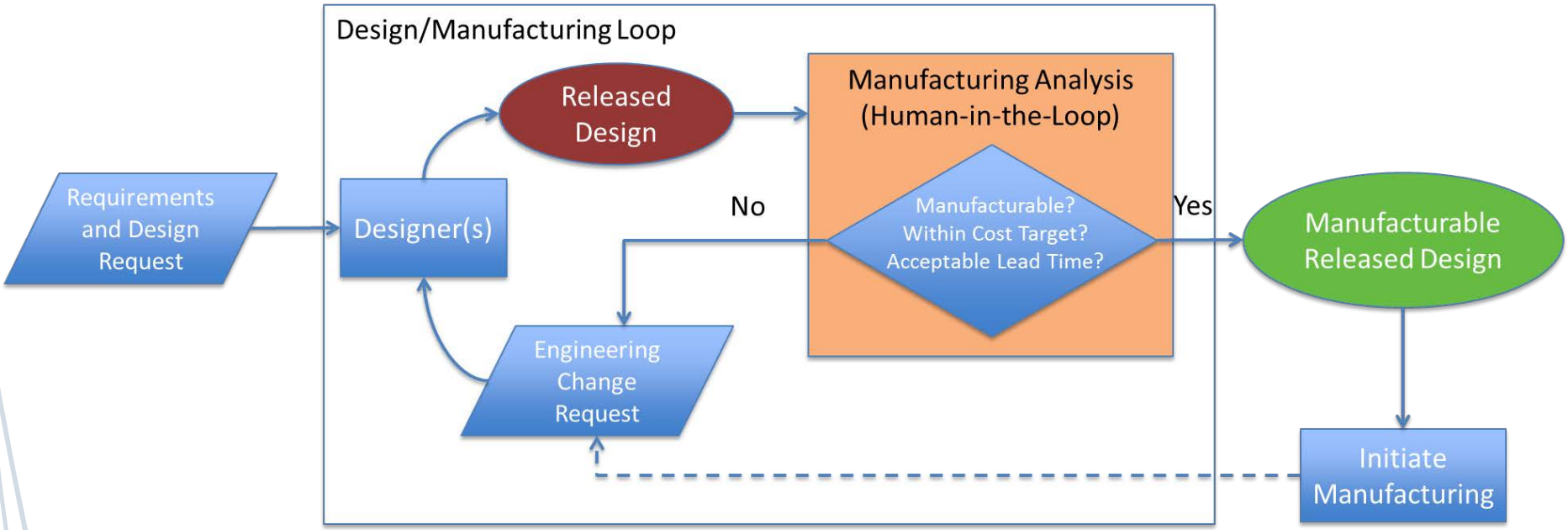

Current State Design / Manufacturing Interaction
(human-in-the-loop manufacturing analysis after design release)

Proposed Solution & Outcomes

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- **Future State of Technology**
  - *Design Assist Tools* for efficient manufacturing data specification *during* design
  - *Automated* manufacturability feedback *during* the design process
    - Confirmed *manufacturable* design prior to manufacturing release
  - Cost roll-ups at *different levels of detail* (component, sub-system, system)
  - Matured Manufacturability Analysis System demonstrated on an existing product line to validate implementation benefits in Industry and DoD/Government
  - System specification ready for implementation at design/manufacturing organizations with validated results/benefits from Use Case

Proposed Solution & Outcomes

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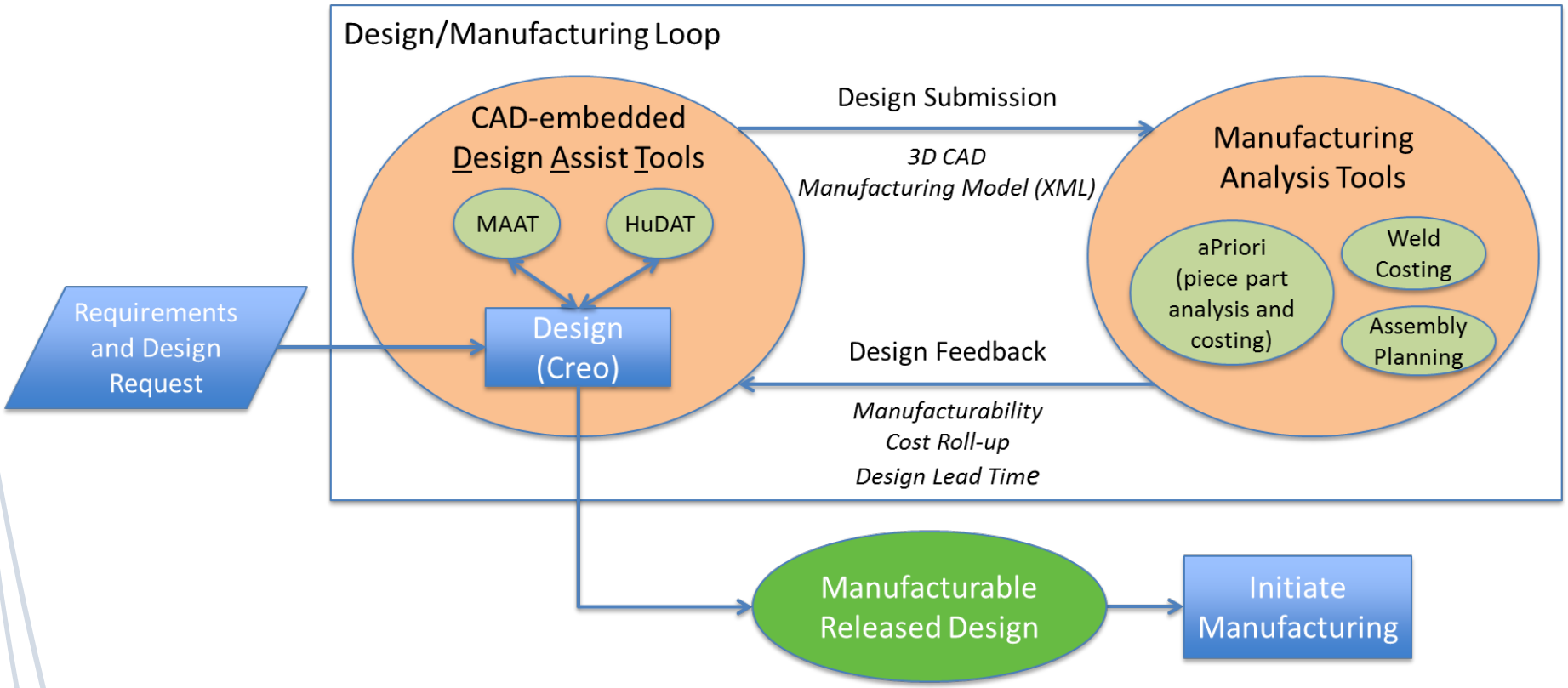

Proposed Design / Manufacturing interaction
(automated manufacturing analysis throughout design using iFAB tool chain)

Proposed Solution & Outcomes

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- Goals and Objectives:
  - Reduce product development time (DARPA AVM goal)
    - Less manual labor in manufacturing data specification and developing product cost roll-ups
  - Reduce Engineering Change Requests
    - Lower risk of non-manufacturable designs being released to production
  - Provide accurate product cost roll-ups at multiple levels of detail
    - Component – Assembly – Sub-System – Total Product
- Benefits realized after full-scale implementation of the Manufacturability Analysis System architecture
  - Oshkosh – 2017
  - Industry and DoD/Govt - 2018

Scope of Work

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- Task 1 – Evaluate Current State iFAB Tools (mo 1-3, Oshkosh lead)
  - Includes Design Assist Tools and manufacturability analysis/feedback tools
- Task 2 – Modify iFAB Manufacturability Analysis System (mo 3-7, ARL lead)
  - Establish requirements for tool extension
  - Modify software to meet requirements
- Task 3 – Configure Manufacturing Models (mo 2-7, aPriori lead)
  - Enable cost estimation for fabricated parts (machined, plate/sheet, casting, bar/tube)
  - Configure aPriori Virtual Production Environments for bulk load use in MAS
- Task 4 – Integrate iFAB Tools with Internal Oshkosh Component Model Library (mo 5-7, ARL lead)
  - Mechanism for retrieval of cost/lead time of non-fabricated components

Scope of Work

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- Task 5 – Integrate iFAB Tools with PLM System (mo 5-8 – ARL lead)
  - Enable data management of product design, manufacturing data specification, and manufacturability analyses
  - Lead – ARL Penn State
- Task 6 – Evaluate Modified iFAB MAS (mo 7-8, Oshkosh lead)
  - Confirm tool modification requirements (Task 2) have been achieved
- Task 7 – Execute Use Case for Existing Product Line (mo 7-12, ARL/Oshkosh lead)
  - Using existing Oshkosh product line (e.g., JLG access lift), conduct design and manufacturability analysis exercise
  - Document product development process and compare to traditional methods
- Task 8 – Implementation Support (mo 12, ARL Lead)
  - Define software requirements and hardware recommendations for industry implementation
  - Includes summary of potential commercialization

Manufacturing Analysis System

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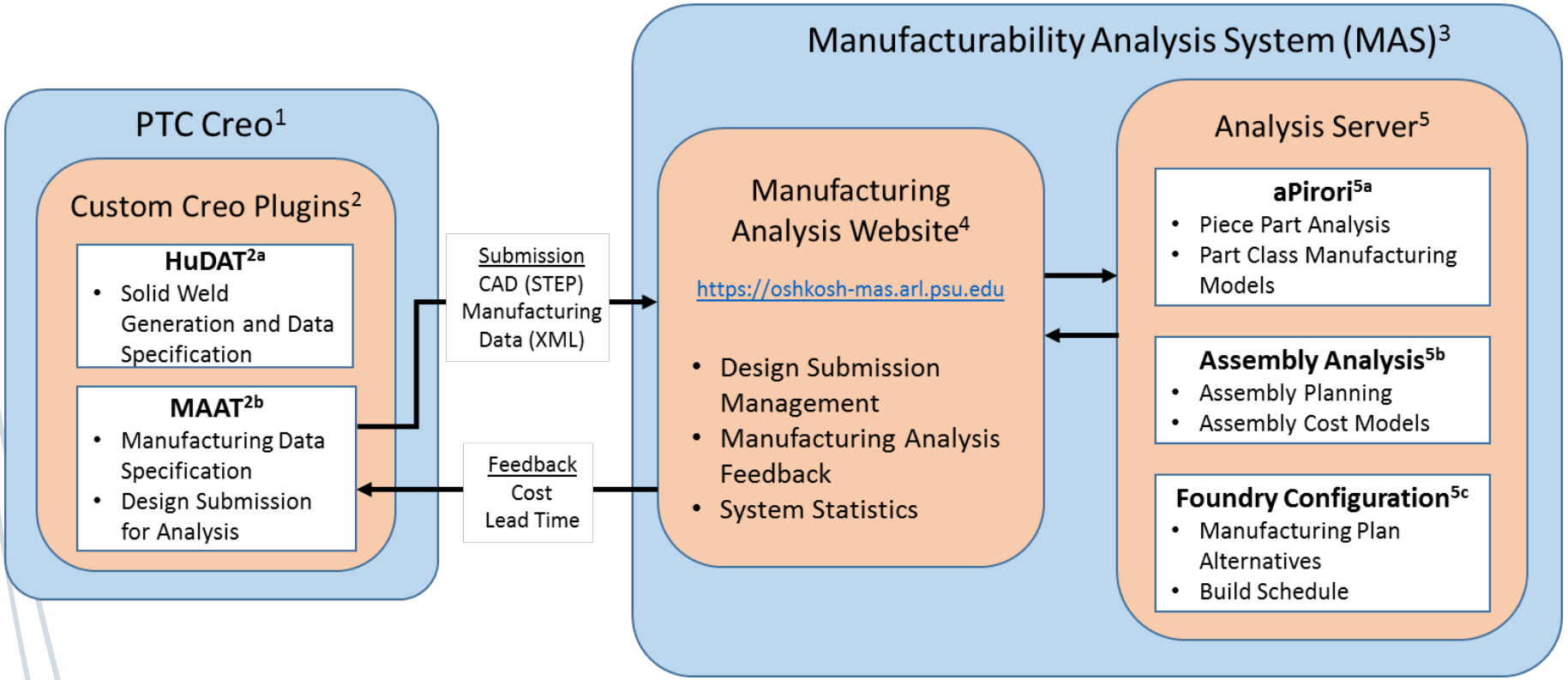

Manufacturing Analysis System
1. PTC Creo

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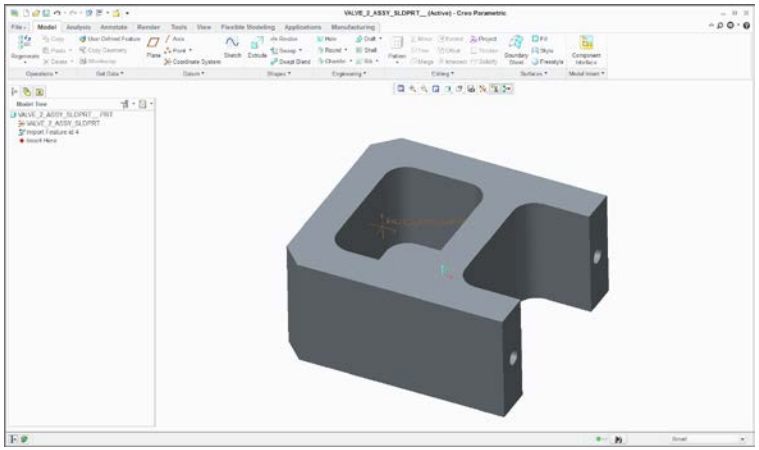
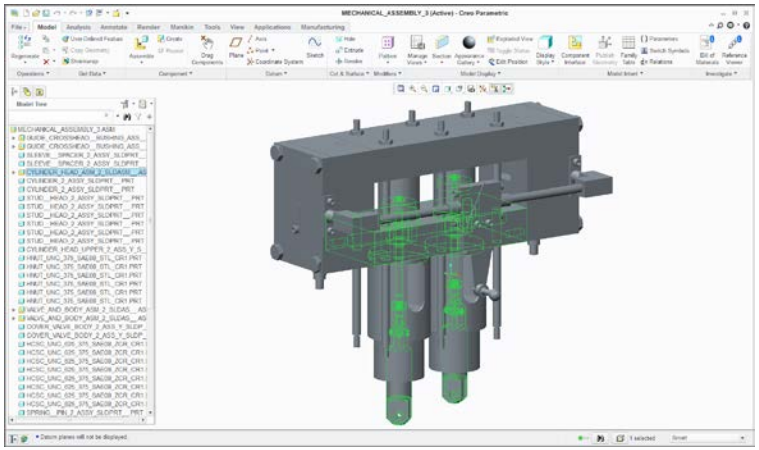
- Creo was required CAD system for AVM tool chain
- Software evaluation activities will assume the use of Creo
  - Creo designs either designed natively or imported from STEP (parts and assemblies)
  - Version 2.0 well tested
    - Need to consider upgrade plans to 3.0
- *Note: MAS does not use native Creo input (STEP)*





Manufacturing Analysis System
2b. MAAT

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- Custom plugin (Java-based)
- Allows designers to specify manufacturing data for analysis in the MAS
- Piece part specification (Machined, Plate/Sheet, Casting, Pipe/Bar/Tube)
- Assembly specification (Mechanical, Welded, Bonded)
  - Automated assembly seam identification based on part-to-part interferences
- Direct submission to MAS
- Receipt and display of manufacturability feedback

Manufacturing Analysis System
2b. MAAT

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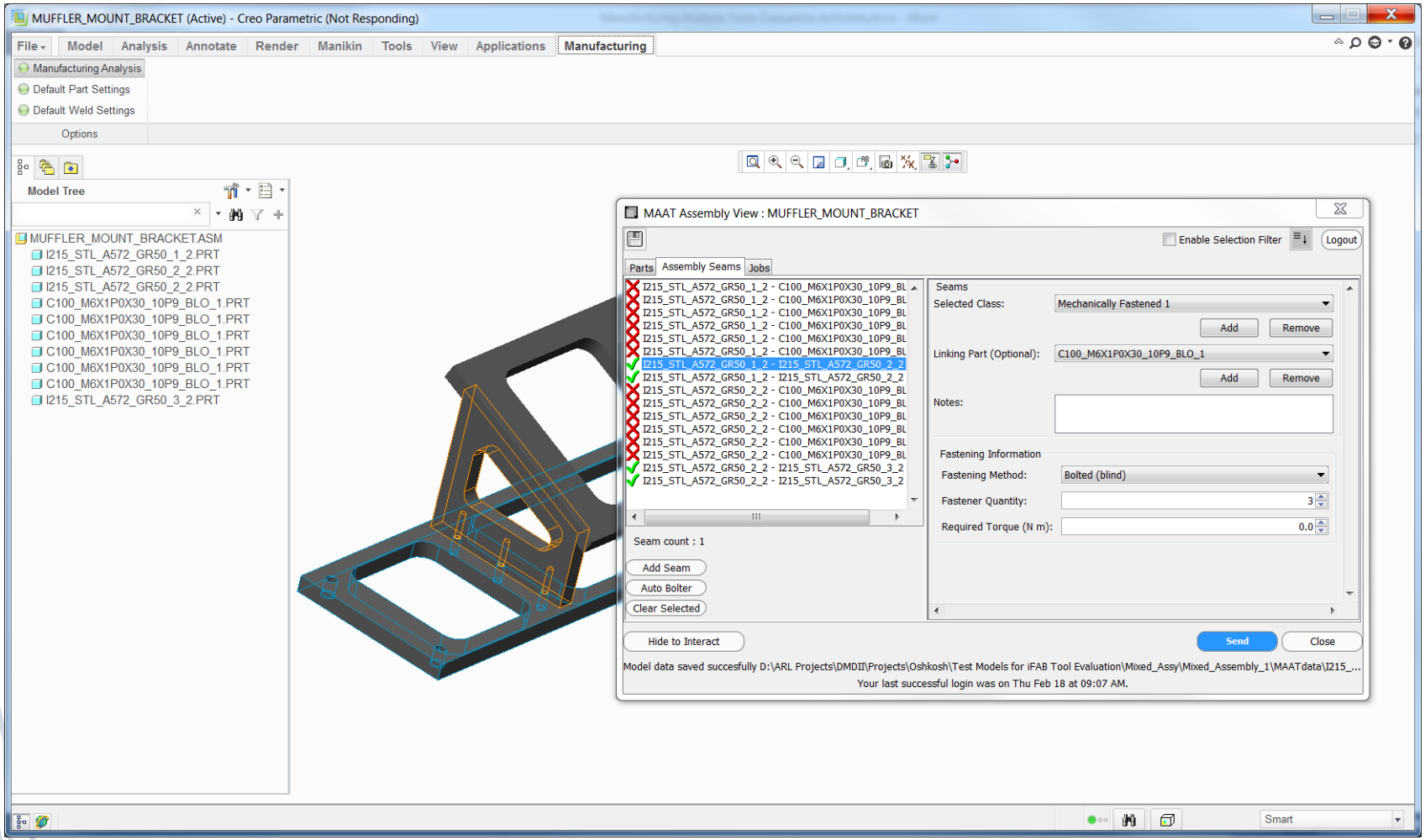

MAAT Interface in Creo 2.0 (example: assembly seam specification)

Manufacturing Analysis System
2b. MAAT

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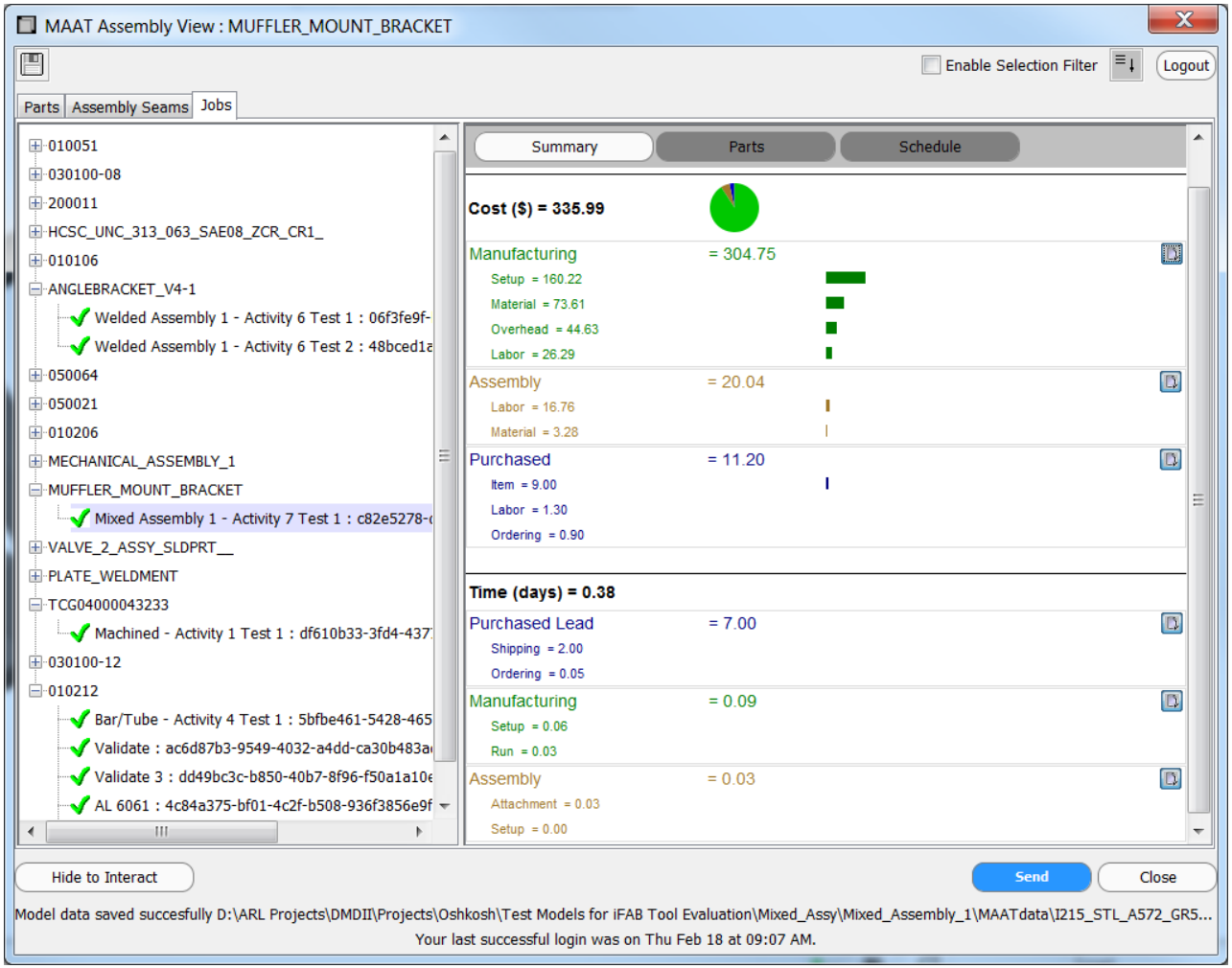

Manufacturability Feedback in MAAT

Manufacturing Analysis System
2a. HuDAT

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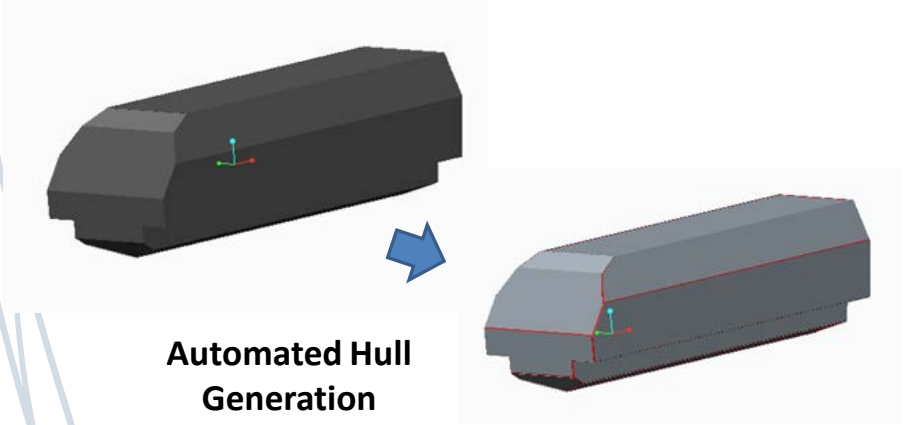
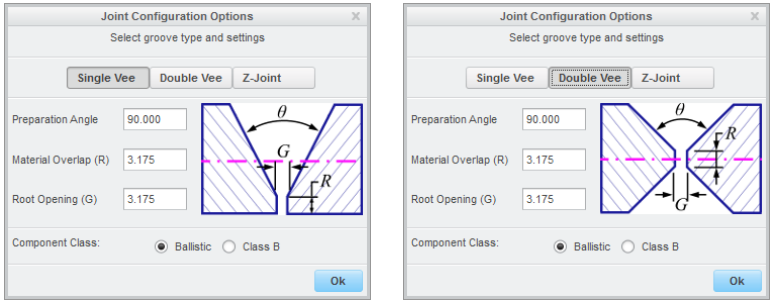
- Custom plugin originally developed to support the detailed design of ground vehicle hull structures
  - Ballistic qualifiable weld joints
- Automated feature generation for edge preparation and solid weld geometry
  - Storage of weld details as parameters on weld part
- Development of as-cut plates in addition to final geometry
- Manual generation of solid welds and data required in MAS



Automated Hull Generation



Joint Creation

Manufacturing Analysis System
2a. HuDAT

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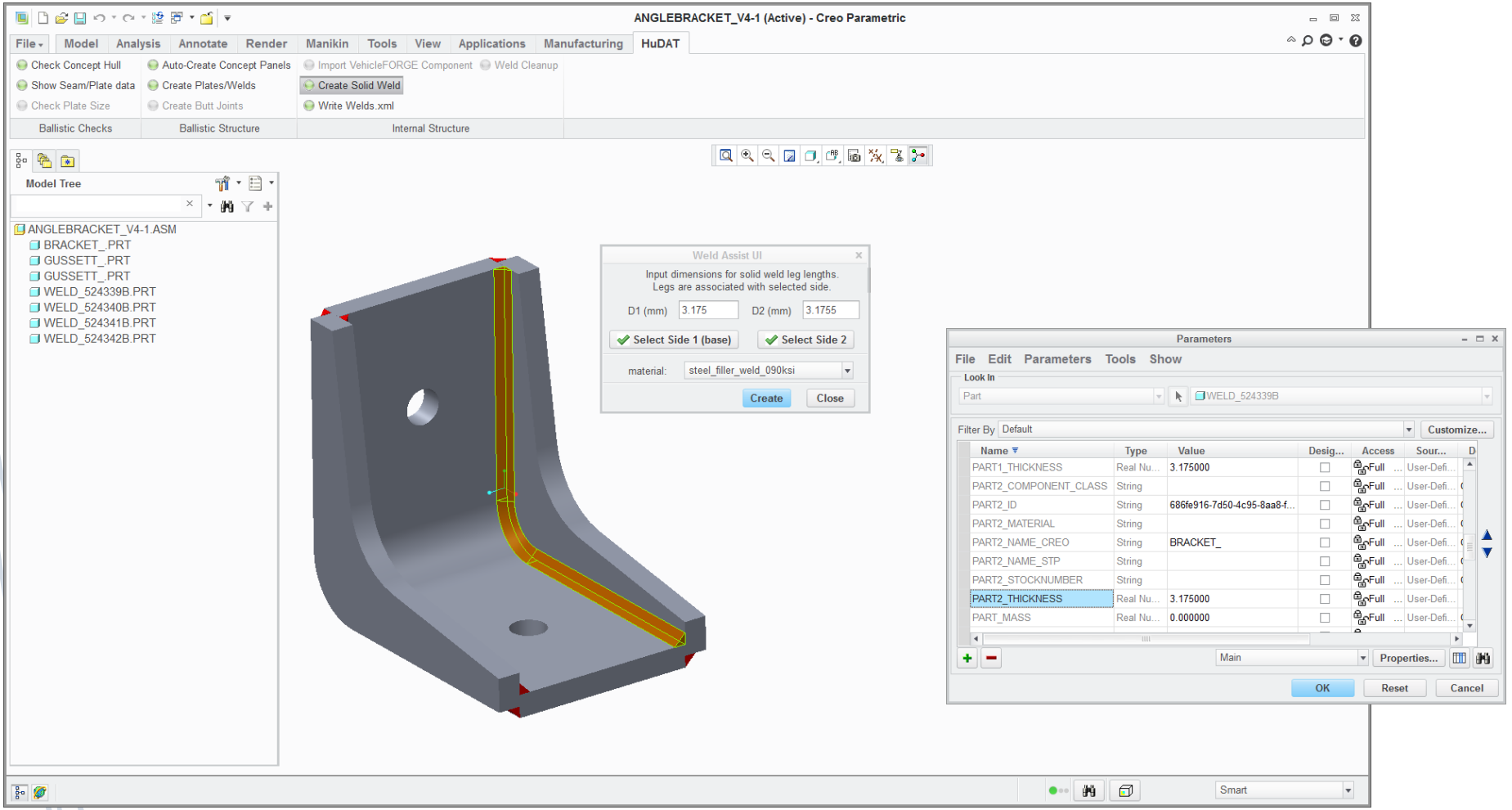

Solid Weld Generation in HuDAT

Manufacturing Analysis System
3. MAS

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- Primary software architecture developed in DARPA AVM/iFAB
- Includes:
  - Manufacturing Analysis Website (4)
  - Analysis Server (5)
- Currently hosted on a server at ARL Penn State
  - No client installation required
- System specification will include details on how industrial partner can stand up MAS internally

Manufacturing Analysis System
4. Manufacturing Analysis Website

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- Originally developed for management of design submissions from many users during AVM program
- Receives design submission data from MAAT and passes the information to the analysis server
- User accounts are created for MAAT users to allow them to access the site from a web browser to review their design submissions
- Also currently maintains MAS statistics including submission counts, analysis times, and user details

Manufacturing Analysis System
4. Manufacturing Analysis Website

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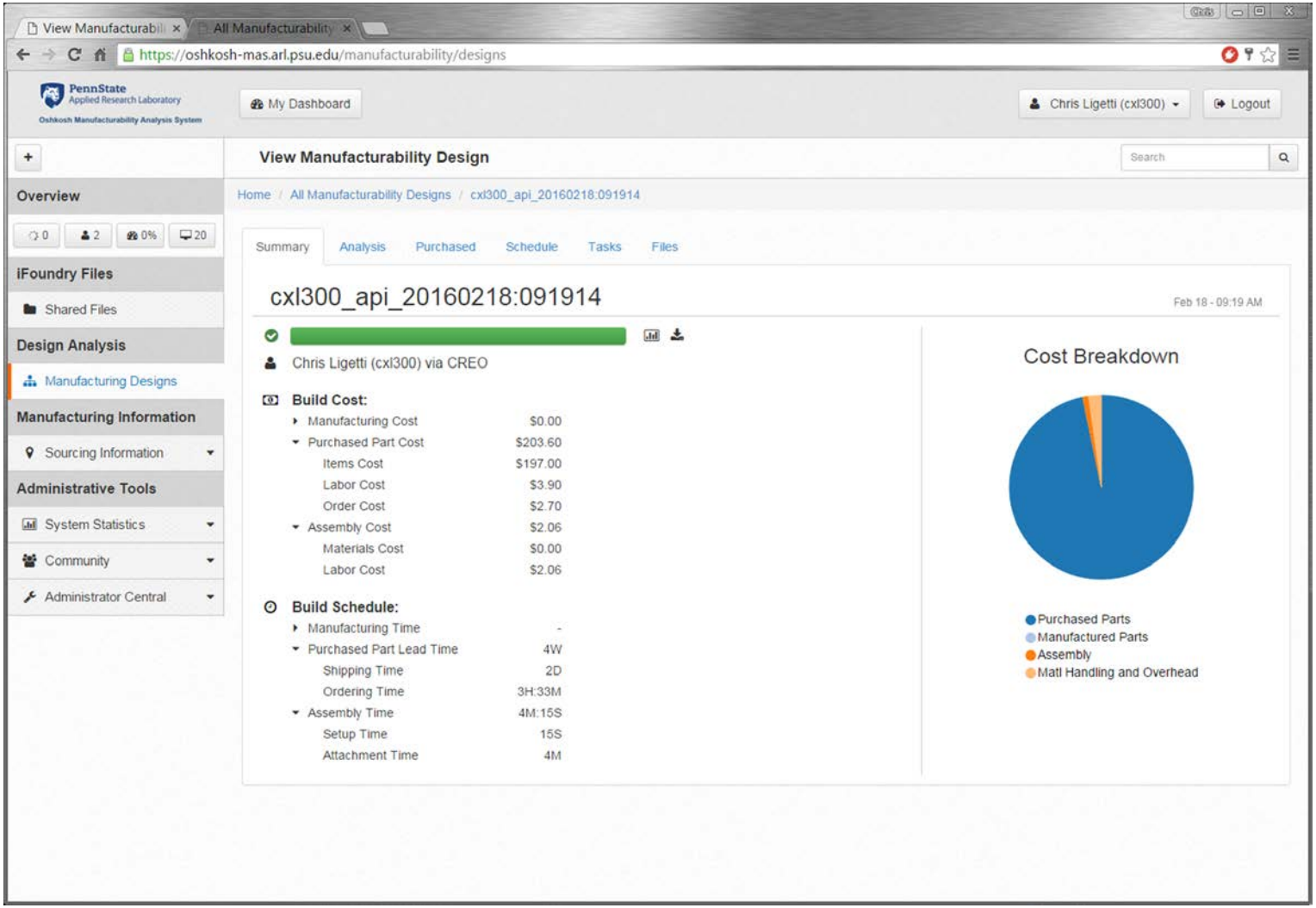

Manufacturability Analysis Results/Feedback in Manufacturing Analysis Website

Manufacturing Analysis System
5. Analysis Server

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- Manufacturability analysis is conducted by various modules depending on the design component type (e.g., machined part, welded assembly)
- Mix of custom software developed in the AVM program as well as commercial software
- Individual analysis modules are not required to be installed on each user's machine
- Server-based analysis allows for more efficient distribution of the computation requirements

Manufacturing Analysis System
5. Analysis Server

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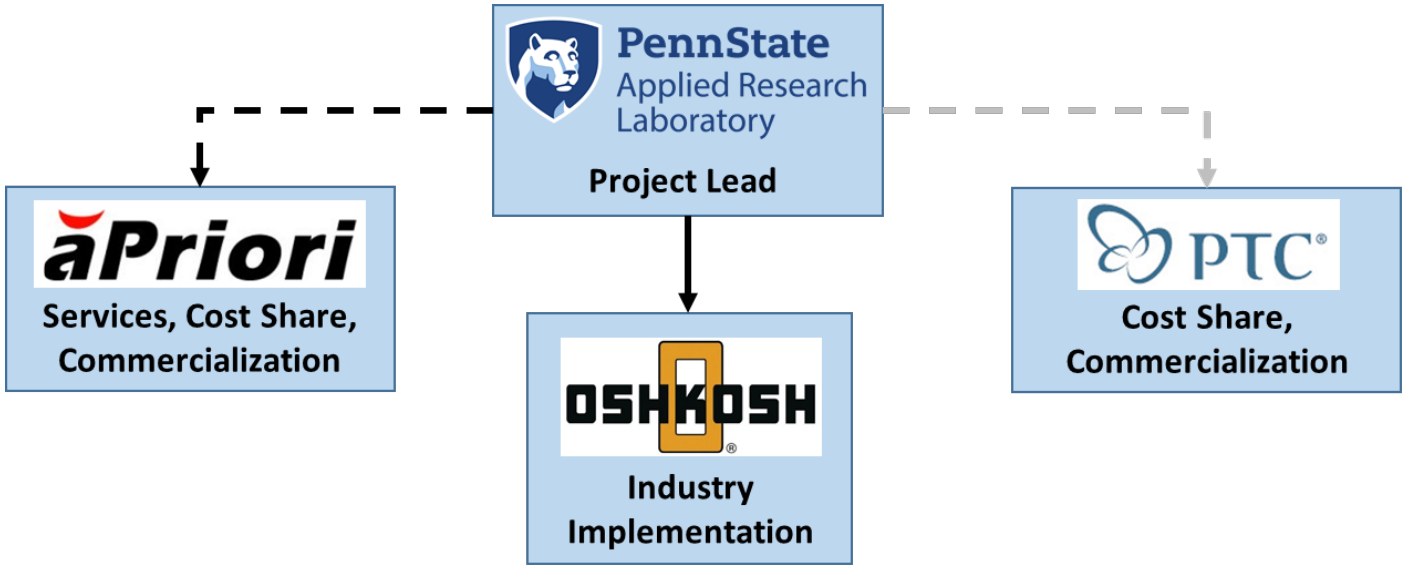
a. aPriori
   - Commercial software package that estimates cost and manufacturing time for piece parts
   - Inputs include the CAD model and process options that are extracted from the manufacturing data specified MAAT
   - Predicts process plans and costs based on manufacturing models (VPEs) stored on the analysis server

b. Assembly Analysis
   - Collection of custom-developed software applications that process assembly data specifications obtained from MAAT
   - Analyzes sequence alternatives, and predicts assembly cost and time based on the attachment mechanisms and the masses of the assembled parts

c. Foundry Configuration
   - Enumeration of all manufacturing build plans for a given product (e.g., process, machine, sequence, etc.)
   - Analyzes alternatives, seeking to generate the cost vs. lead time pareto front

Assisting Organizations



Organization	Role	Partner Contributions & Responsible Tasks
ARL Penn State	Project Lead	Program management, Transition of the iFAB Manufacturability Assessment System to the Oshkosh Environment, Analysis Support, and Training and Documentation
Oshkosh	Subcontractor; Industry Implementation	Industrial partner for use case, technology transition, validation, and commercialization.
aPriori	Services and Cost Share	Software partner for commercialization and analysis support
PTC	Cost Share	Software partner for post-project commercialization evaluation

Success Criteria & KPIs

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Deliverable	Success Criteria / KPI
Manufacturability Analysis System, to include the following software interfaces: (MAAT, PTC Windchill, aPriori, Manufacturability Analysis Website)	• Manufacturability feedback is rapid and accurate • Interfaces to Component Model database and PLM system are complete • Use case exercise demonstrates quantifiable savings in product development time with added analysis capability
Design Assist Tools (Creo Plug-ins, HuDAT and MAAT)	• DATs enable sufficient manufacturing data specification for manufacturing analysis and cost estimation
System Specification Document	• System specification adequately supports full-scale deployment of MAS to Oshkosh and other industrial organizations
Transition Plan	
Software User Guides	• Technology developer support not required for post-project industry implementation and end-use support